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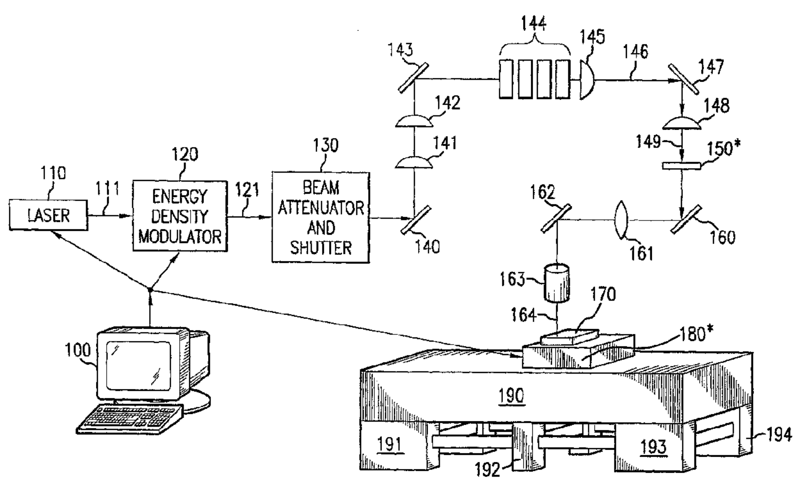
(54) **Title:** METHOD AND SYSTEM FOR PROVIDING A CONTINUOUS MOTION SEQUENTIAL LATERAL SOLIDIFICATION FOR REDUCING OR ELIMINATING ARTIFACTS, AND A MASK FOR FACILITATING SUCH ARTIFACT REDUCTION/ELIMINATION



(57) **Abstract:** An arrangement, process and mask for implementing single-scan continuous motion sequential lateral solidification of a thin film provided on a sample such that artifacts formed at the edges of the beamlets irradiating the thin film are significantly reduced. According to this invention, the edge areas of the previously irradiated and resolidified areas which likely have artifacts provided therein are overlapped by the subsequent beamlets. In this manner, the edge areas of the previously resolifiied irradiated areas and artifacts therein are completely melted throughout their thickness. At least the subsequent beamlets are shaped such that the grains of the previously irradiated and resolidified areas which border the edge areas melted by the subsequent beamlets grow into these resolidifying edges areas so as to substantially reduce or eliminate the artifacts.

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METHOD AND SYSTEM FOR PROVIDING A CONTINUOUS MOTION SEQUENTIAL LATERAL SOLIDIFICATION FOR REDUCING OR ELIMINATING ARTIFACTS, AND A MASK FOR FACILITATING SUCH ARTIFACT REDUCTION/ELIMINATION

SPECIFICATION

FIELD OF THE INVENTION

The present invention relates to a method, system and mask for processing a thin-film semiconductor material, and more particularly to forming large-grained, grain-shaped and grain-boundary-location controlled semiconductor thin films from amorphous or polycrystalline thin films on a substrate by continuous motion-scanning the entire sample or at least one portion thereof using a sequential lateral solidification technique so as to reduce or even eliminate artifacts, e.g., that may be formed in overlapped irradiated, melted and resolidifying regions of a sample or in the portion(s) thereof.

BACKGROUND INFORMATION

In the field of semiconductor processing, a number of techniques have been described to convert thin amorphous silicon films into polycrystalline films. For example, in James Im et al., "Crystalline Si Films for Integrated Active-Matrix Liquid-Crystal Displays," 11 MRS Bulletin 39 (1996), an overview of conventional excimer laser annealing technology is described. In such conventional system, an excimer laser beam is shaped into a beam having an elongated cross-section which is typically up to 30 cm long and 500 micrometers or greater in width. The shaped beam is stepped over a sample of amorphous silicon (i.e., by translating the sample) to facilitate melting thereof and to effectuate the formation of grain-shape and grain boundary-controlled polycrystalline silicon upon the re-solidification of the sample. Such techniques has been referred to as sequential lateral solidification ("SLS") of the melted portions of the

sample to effectuate the growth of longer grain boundaries therein so as to achieve, e.g., uniformity among other thing.

Various techniques, processes, masks and samples have been previously described which utilize various SLS techniques, to effectively process the sample. For example, International Publication No. 02/086954 describes a method and system for providing a single-scan, continuous motion sequential lateral solidification of melted sections of the sample being irradiated by beam pulses. In this publication, an accelerated sequential lateral solidification of the polycrystalline thin film semiconductors provided on a simple and continuous motion translation of the semiconductor film are achieved, without the necessity of "microtranslating" the thin film, and re-irradiating the previously irradiated region in the direction which is the same as the direction of the initial irradiation of the thin film while the sample is being continuously translated.

One problem that may arise during SLS processing of a thin film provided on a sample is microstructural artifacts, e.g., grain misalignment. For example, these artifacts may be formed in the area of beamlet overlap. Such areas in which artifacts may form may be tail areas of the newest beamlet(s) irradiating the sample which overlap front or head areas of the previously irradiated and resolidified portion of the sample. These artifacts may arise because the edge of the beam (e.g., rounded or square-shaped), which is reproduced in the molten portion, leads to lateral growth of grains extending in from the edges at angles that are skewed to the desired direction of the lateral growth.

OBJECT AND SUMMARY OF THE INVENTION

An object of the present invention is to provide techniques for forming large-grained, grain-shaped and grain-boundary-location controlled polycrystalline thin film semiconductors using a sequential lateral solidification ("SLS") process, and to reduce or eliminate artifacts.

According to the present invention, an arrangement, process and mask are provided for implementing single-scan continuous motion sequential lateral solidification

of a thin film situated on a sample such that artifacts are reduced or eliminated. For example, according to the present invention artifacts that may be formed at the edges of the beamlets irradiating the thin film are significantly reduced. According to this invention, the edge areas of the previously irradiated and resolidified areas which likely have artifacts provided therein are overlapped by the subsequent beamlets. In this manner, the edge areas of the previously resolidified irradiated areas and artifacts therein are completely melted throughout their thickness. At least the subsequent beamlets are shaped such that the grains of the previously irradiated and resolidified areas which border the edge areas melted by the subsequent beamlets grow into these resolidifying edges areas so as to substantially reduce or eliminate the artifacts.

In one exemplary embodiment of the present invention, an arrangement, process and mask can be provided for processing at least one portion of a thin film sample on a substrate. In particular, an irradiation beam generator can be controlled to emit successive irradiation beam pulses at a predetermined repetition rate. The exemplary mask may receive thereon each of the irradiation beam pulses. Such mask can include a beam pattern which, when the beam pulses irradiate therethrough, defines one or more first beamlets and one or more second beamlets, with each of the first and second beamlets having two opposite edge sections and a center section. The first beamlets can irradiate one or more first areas of the film sample so that the first areas are melted throughout their thickness.

At least one first section of the first areas irradiated by at least one particular beamlet of the first beamlets is allowed to re-solidify and crystallize thereby having grains grown therein. The first section includes at least one first resolidified area irradiated by the one of the edge sections of the particular beamlet, the first resolidified area including artifacts therein. After the one or more first areas are irradiated, the second beamlets irradiate one or more second areas of the film sample so that the second areas are melted throughout their thickness. At least one second section of the second areas irradiated by the subsequent beamlet is allowed to re-solidify and crystallize thereby having grains grown therein. The second section includes at least one second

resolidified area irradiated by the at least one of the edge sections of the subsequent beamlet which overlaps the artifacts provided in the first resolidified area. In this manner, the artifacts can thus be substantially reduced or even eliminated upon the resolidification of the second section of the second area.

According to another exemplary embodiment of the present invention, the edge sections of each of the first and second beamlets are a front section and a rear section. The first resolidified area can be irradiated by the rear section of the particular beamlet, and the second resolidified area may be irradiated by the front section of the subsequent beamlet. The rear section of at least one particular beamlet has a width for a substantial length thereof which is smaller than a width of the center section of the particular beamlet. In addition, the front section of at least one subsequent beamlet of the second beamlets has a width for a substantial length thereof which is smaller than a width of the center section of the subsequent beamlet.

In yet another exemplary embodiment of the present invention, the rear section of the particular beamlet and the front section of the subsequent beamlet have substantially straight edges in which the straight edges slope toward one another and away from the center section of the respective one of the particular and subsequent beamlets. Also, the rear section of the particular beamlet and the front section of the subsequent beamlet can have a triangular shape. For example, each of the front and rear sections has three apexes, and one of the apexes of each of the front and rear sections points away from the central section of a respective one of the particular and subsequent beamlets. In yet another exemplary embodiment, the rear section of the particular beamlet and the front section of the subsequent beamlet have a trapezoid shape. Thus, the trapezoid-shaped rear section of the particular beamlet may have a first conceptual side extending for a width of the central section of the particular beamlet and a second side provided at an edge of the rear section away from the central section, with the first side being greater than the second side. The trapezoid-shaped front section of the subsequent beamlet can have a third conceptual side extending for a width of the central section of the subsequent beamlet, and a fourth side provided at an edge of the front section away

from the central section. The third side is preferably greater than the fourth side. In another embodiment of the present invention, upon the resolidification of the second section of the second area, at least most of the grains from the resolidified first section of the first area that are adjacent to the second section grow into the solidifying second section in a direction which is approximately perpendicular to a direction of extension of the solidifying second section.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the present invention will now be described in further detail with reference to the accompanying drawings in which:

Figure 1 shows a diagram of an exemplary embodiment of a system for performing a single-scan, continuous motion sequential lateral solidification ("SLS") according to the present invention which does not require a microtranslation of a sample for an effective large grain growth in a thin film, and effectuates a bi-directional grain growth within the irradiated and re-solidified area of the sample;

Figure 2A shows an enlarged illustration of a first mask utilized by the conventional systems and methods having a rectangular shape, which facilitates the single-scan, continuous motion SLS as an intensity pattern generated thereby impinges the thin film on a substrate of the sample, and using which microstructural artifacts may possibly form;

Figure 2B shows an enlarged view of the resolidified region of the sample irradiated by one exemplary beamlet shaped by the mask of Figure 2A which overlaps a portion of the previously resolidified region, as well as artifacts formed at the overlapped area;

Figure 2C show an exemplary sequential stage of the SLS processing of the sample using the mask of Figure 2A and the grain structures on the resolidified areas of the sample which shows microstructural artifacts provided in the areas where the previously-irradiated and resolidified areas have been overlapped by the newly irradiated and resolidified areas;

Figure 3A shows an enlarged illustration of a second mask having a round or curved edges that may be utilized by the conventional systems and methods which facilitates the single-scan, continuous motion SLS, and using which microstructural artifacts may possibly form;

Figure 3B shows an enlarged view of the resolidified region of the sample irradiated by one exemplary beamlet shaped by the mask of Figure 3A which overlaps a portion of the previously resolidified region, as well as the illustration of the artifacts formed at the overlapped area;

Figure 4A shows an enlarged illustration of a first exemplary embodiment of the mask utilized by the system and method according to the present invention having a triangular shape at the edges thereof using which microstructural artifacts may be reduced or eliminated;

Figure 4B shows an enlarged view of the resolidified region of the sample irradiated by one exemplary beamlet shaped by the mask of Figure 4A which overlaps a portion of the previously resolidified region, and illustrates the reduction or elimination of the artifacts;

Figure 4C show an exemplary sequential stage of the SLS processing of the sample using the mask of Figure 3A and the grain structures on the resolidified areas of the sample which shows the reduction or elimination of the microstructural artifacts provided in the areas where the previously-irradiated and resolidified areas have been overlapped by the newly irradiated and resolidified areas; and

Figure 5A shows an enlarged illustration of a second exemplary embodiment of the mask utilized by the system and method according to the present invention having a tapered shape at the edges thereof using which microstructural artifacts may be reduced or eliminated.

DETAILED DESCRIPTION

Certain systems and methods for providing a single scan, continuous motion SLS are described in International Publication No. 02/086954 (the "'954

Publication"), the entire disclosure of which is incorporated herein by reference. The '954 Publication explicitly describes and illustrates the details of these systems and methods, and their utilization of microtranslations of a sample, which may have an amorphous silicon thin film provided thereon that can be irradiated by irradiation beam pulses so as to promote the sequential lateral solidification on the thin film, without the need to microtranslate the sample and/or the beam relative to one another to obtain a desired length of the grains contained in the irradiated and re-solidified areas of the sample. Similar to the system described in the '954 Publication, an exemplary embodiment of a system for carrying out the continuous motion SLS processing of amorphous silicon thin films and reduce or eliminate microstructural artifacts according to the present invention is illustrated in Figure 1. The exemplary system includes a Lambda Physik model LPX-315I XeCl pulsed excimer laser 110 emitting an irradiation beam (e.g., a laser beam), a controllable beam energy density modulator 120 for modifying the energy density of the laser beam, a MicroLas two plate variable attenuator 130, beam steering mirrors 140, 143, 147, 160 and 162, beam expanding and collimating lenses 141 and 142, a beam homogenizer 144, a condenser lens 145, a field lens 148, a projection mask 150 which may be mounted in a translating stage (not shown), a 4×-6× eye piece 161, a controllable shutter 152, a multi-element objective lens 163 for focusing an incident radiation beam pulse 164 onto a sample 170 having a silicon thin film 52 to be SLS processed mounted on a sample translation stage 180, a granite block optical bench 190 supported on a vibration isolation and self-leveling system 191, 192, 193 and 194, and a computer 106 (e.g., a general purpose computer executing a program or a special-purpose computer) coupled to control the pulsed excimer laser 110, the beam energy density modulator 120, the variable attenuator 130, the shutter 152 and the sample translation stage 180.

The sample translation stage 180 may be controlled by the computer 106 to effectuate translations of the sample 40 in the planar X-Y directions and the Z direction. In this manner, the computer 106 controls the relative position of the sample 40 with respect to the irradiation beam pulse 164. The repetition and the energy density of

the irradiation beam pulse 164 may also be controlled by the computer 106. It should be understood by those skilled in the art that instead of the pulsed excimer laser 110, the irradiation beam pulse can be generated by another known source of short energy pulses suitable for melting a semiconductor (or silicon) thin film. Such known source can be a pulsed solid state laser, a chopped continuous wave laser, a pulsed electron beam and a pulsed ion beam, etc. with appropriate modifications to the radiation beam path from the source 110 to the sample 170. In the exemplary embodiment of the system shown in Figure 1, while the computer 106 controls translations of the sample 170 for carrying out the single-scan, continuous motion SLS processing of the thin film according to the present invention, the computer 100 may also be adapted to control the translations of the mask 150 and/or the excimer laser 110 mounted in an appropriate mask/laser beam translation stage (not shown for the simplicity of the depiction) to shift the intensity pattern of the irradiation beam pulses 164, with respect to the silicon thin film, along a controlled beam path. Another possible way to shift the intensity pattern of the irradiation beam pulse is to have the computer 100 control a beam steering mirror. The exemplary system of Figure 1 may be used to carry out the single-scan, continuous motion SLS processing of the silicon thin film on the sample 170 in the manner using conventional masks, as well as those used according to the exemplary embodiments of the present invention. The details of such processing are set forth in further detail below.

An amorphous silicon thin film sample may be processed into a single or polycrystalline silicon thin film by generating a plurality of excimer laser pulses of a predetermined fluence, controllably modulating the fluence of the excimer laser pulses, homogenizing the intensity profile of the laser pulse plane, masking each homogenized laser pulses to define beamlets, irradiating the amorphous silicon thin film sample with the beamlets to effect melting of portions thereof that were irradiated by the beamlets, and controllably and continuously translating the sample 170 with respect to the patterned beamlets. The output of the beamlets is controllably modulated to thereby process the amorphous silicon thin film provided on the sample 170 into a single or grain-shape, grain-boundary-location controlled polycrystalline silicon thin film by the continuous

motion sequential translation of the sample relative to the beamlets, and the irradiation of the sample by the beamlets of masked irradiation pulses of varying fluence at corresponding sequential locations thereon. One of the advantages of the system, method and mask according to the present invention is that the ability to reduce or eliminate the microstructural artifacts that may be formed on the areas on the sample in which edges (e.g., rear edges) of the newly irradiated and solidifying region of the sample 170 partially overlap edges (e.g., front edges) of the previously resolidified region of the sample 170.

Figure 2A shows an enlarged illustration of a first mask 150 that has rectangular-shaped slits, as used in conventional continuous motion SLS-type systems and processes. These slits shape the beam being passed therethrough to produce an intensity pattern that impinges the thin film provided on the sample 170, and to be in a shape that is substantially the same as the shape of the corresponding slit. In particular, the slits of the mask 150 allow the respective portions of the beam 149 to irradiate therethrough, while other sections of the mask 150 are opaque, and do not allow the portions of the beam 149 to be transmitted through these opaque sections. This mask 150 includes a first set of rectangular-shaped slits 210 situated at an offset from one another along a negative Y-axis, and a second set of rectangular-shaped slits 215 are also provided at an offset from one another along a negative Y-axis, but also distanced from the first slits. The positioning of the first and second slits with respect to one another is shown and described in further detail in the '954 Publication.

Figure 2B shows an exemplary illustration of the irradiation of the sample 170 by a sample beamlet of the intensity pattern shaped by the mask of Figure 2A. In operation, this beamlet is irradiated on the sample so as to partially cover a portion (e.g., a front portion 265) of the previously irradiated, melted and resolidified area of the sample with its own portion (e.g., a tail portion 270). For example, the front portion 265 of the previously-resolidified area may have the grains grown in the orientation that is approximately parallel to the direction of the translation of the sample 170 and/or the beam pulse 164. Upon the irradiation of the next sequential region by the subsequent

beamlet, a part of the front portion 265 is overlapped by the tail portion 270 of such beamlet, so as to completely melt, resolidify and form respective portions of the subsequent region 250, including a new front portion 260 and the tail portion 270. The grains of the front portion 265 of the previously resolidified region extend at angles that are contrary to the desirable direction of grain growth.

For example, the grains may extend approximately along the relative translation direction of the sample, which is unfavorable for processing the sample according to the continuous motion SLS-techniques. Such undesired grain growth is shown for the new front portion 260, which illustrates that that grains grow from the edges of the irradiated and fully melted region 250, such that at least some of the grains extend along the length of the region 250, thus potentially producing undesirable effects. On the other end, the undesirable grains that exist in the portion of the previously resolidified region 265 (extending approximately along the length of such region) grow into the tail portion 270 of the newly irradiated, melted and resolidifying region. Accordingly, the tail portion 270 of the resolidifying region 250 may have undesirably-oriented grains provided therein.

Figure 2C illustrates a section of the sample 170 which has been processed by one 610 two 620 and three 630 sequential intensity profiles produced by the mask of 150 of Figure 2A. The undesired grain growth described above with reference to Figure 2B is shown herein. In addition, the previously solidified region 275 (which has the head portion 265 with the grains extending in an undesired manner) has a bottom region 280 with grains that extend into a top portion 285 of a further resolidifying region by seeding the resolidifying portions thereof with the grains of the bottom region 280. This further region is melted by the beamlet that is produced by the slits (215 and 210) of the mask 150 of Figure 2B. Such further region also includes a respective front portion 295 in which undesired grains are grown as described above.

Figure 3A shows an enlarged illustration of a second mask 150 that has slits with rounded edges, as used in conventional continuous motion SLS-type systems and processes. It is also possible for the edges to have a circular shape as well in this

mask 150. This mask 150 includes a first set of round-edge slits 310 situated at an offset from one another along a negative Y-axis, and a second set of round-edge slits 315 are also provided at an offset from one another along a negative Y-axis, but also distanced from the first slits. The positioning of the first and second slits 310, 315 with respect to one another is substantially similar to that of the first and second slits 210, 215.

Figure 3B shows an exemplary illustration of the irradiation of the sample 170 by a sample beamlet of the intensity pattern shaped by the mask 150 of Figure 3A. In this illustration and similarly to the illustration of Figure 2B, the front portion 365 of the previously-resolidified area may have the grains grown in the orientation that is approximately parallel to the direction of the translation of the sample 170 and/or the beam pulse 164, even though the edges of the resolidifying portions are curved or rounded. Indeed, the fact that the edges of the slits 310, 315 have such shape may promote the undesired grain growth along the direction of the relative translation of the sample 170. Again, a part of the front portion 365 of this previously resolidified is overlapped by the tail portion 270 of the newly melted and solidifying region 350, and such region 250 also includes a new front portion 260 and the tail portion 370. The grains of the front portion 365 of the previously resolidified region extend at angles that are contrary to the desirable direction of grain growth, and producing the microstructural artifacts in the overlapped portions.

In order to reduce or eliminate artifacts, the exemplary mask, method and system according to the present invention are described herein. In particular, Figure 4A shows an enlarged illustration of a first exemplary embodiment of the mask 150 according to the present invention which has slits with tapered areas on the ends thereof, that can be used with continuous motion SLS-type systems and processes according to the present invention. In this exemplary embodiment, both ends of each slit 412, 413 have triangular-shaped sections which point away from the respective slit. As described above with respect to the masks shown in Figures 2A and 2B, these slits shape the beam being passed therethrough to produce an intensity pattern that impinges the thin film provided on the sample 170, and to be in a shape that is substantially the same as the

shape of the corresponding slit. The positioning of the first and second slits with respect to one another approximately similar to that of the first and second slits 210, 215.

Figure 4B shows an exemplary illustration of the irradiation of the sample 170 by a sample beamlet of the intensity pattern shaped by the mask of Figure 2A. In operation, this beamlet is irradiated on the sample so as to partially cover a portion (e.g., a front portion 465) of the previously irradiated, melted and resolidified area of the sample with its own portion (e.g., a tail portion 470). The front portion 465 of the previously resolidified region is produced by a section of the beamlet that is shaped by a triangular portion 412 of the slit 410. The tail portion 470 of the newly melted and resolidifying region 450 is produced by another section of the beamlet that is shaped by the reverse-triangular portion 413 of the slit 410. For example, the front portion 465 of the previously-resolidified area may have very few grains grown in the orientation that is approximately parallel to the direction of the translation of the sample 170 and/or the beam pulse 164. Indeed, because the portion 465 has a tapered (e.g., triangular) shape as shown in Figure 4B, most of the grains grown therein, upon its resolidification, would grow in the direction that is approximately perpendicular to the translation direction of the sample 170 and/or that of the beam pulse 164.

Upon the irradiation of the next sequential region by the subsequent beamlet, a part of the front portion 465 is overlapped by the tail portion 470 of such beamlet, so as to completely melt, resolidify and form respective portions of the subsequent region 450, including a new front portion 460 and the tail portion 470. Such overlap by the tail portion 470 of the region 450 melts at least the very end areas of the front portion 465 of the previously resolidified region. Indeed, these end areas may contain the undesired grains which undesirably grew in the direction of the translation of the sample and/or that of the beam pulse 164. Thus, the properly oriented grains of the front portion 465 would be the primary grains that seed the resolidifying tail portion 470 of the region 450. Therefore, the grains of the resolidifying portion 450 at the tail portion 470 thereof which overlaps the front portion 450 would be oriented in a desired manner (e.g., oriented perpendicularly to the direction of translation of the sample 170 and/or of

the beam pulse 164). Indeed, as shown in Figure 4B, such grain growth minimizes, and possibly eliminates the microstructural artifacts that may exist in the overlapped portions of the resolidified regions.

Figure 4C illustrates a section of the sample 170 which has been processed by one 710 two 720 and three 730 sequential intensity profiles produced by the mask of 150 of Figure 4A. The desired grain growth in the overlapped portions of the resolidified regions described above with reference to Figure 4B is shown herein. In addition, the previously solidified region 475 (which has the head portion 465 with the grains extending in a desired manner) has a bottom region 480 with grains that extend into a top portion 485 of a further resolidifying region by seeding the resolidifying portions thereof with the grains of the bottom region 480. This further region is melted by the beamlet that is produced by slits (410 and 415) of the mask 150 of Figure 4B. Such further region also includes a respective front portion 495 in which the undesired grains are grown as described above. Similarly to the description above with reference to Figure 2C, there is a multiplicity of the regions 450 with the orientation of the grains in the overlapping areas. Thus, the exemplary mask, method and system according to the present invention provides for the reduction and/or removal of microstructural artifacts in the overlapping portions of the resolidified regions.

Figure 5A shows an enlarged illustration of another exemplary embodiment of the mask 150 that has slits with tapered cut-off edges for use with the continuous motion SLS-type systems and processes according to the present invention. This mask 150 includes a first set of tapered cut-off slits 510 situated at an offset from one another along a negative Y-axis, and a second set of tapered cut-off slits 515 are also provided at an offset from one another along a negative Y-axis, but also distanced from the first slits. The positioning of the first and second slits 510, 515 with respect to one another is substantially similar to that of the first and second slits 410, 415.

Figure 5B shows an exemplary illustration of the irradiation of the sample 170 by a sample beamlet of the intensity pattern shaped by the mask 150 of Figure 5A. In this illustration and similarly to the illustration of Figure 4B, the front portion 565 is

produced by the section of the beamlet that is shaped by a tapered portion 512 of the slit 510. This front portion 565 of the previously-resolidified area may have the desirable grains grown in the orientation that is approximately perpendicular to the direction of the translation of the sample 170 and/or the beam pulse 164, and the rear portion 570 that overlaps at least a section of the front portion 565 is produced by the section of the beamlet that is shaped by a tapered portion 513 of the slit 510. This front portion 565 of the previously-resolidified area may have the desirable grains grown in the orientation that is approximately perpendicular to the direction of the translation of the sample 170 and/or the beam pulse 164. Similarly to the description provided above for sequential irradiation of the sample 170 by the mask of Figure 4A, the sections of the tail portion 470 of the region 550 that may have any undesired grains therein are overlapped the front portion 465 of the previously resolidified region, and thus the properly oriented grains seed the melted tail portion 570 of the region 550 such that the grains are desirably grown in the direction that is perpendicular to the direction of the translation of the sample and/or that of the beam pulse 164. In this manner, any existent microstructural artifacts provided in the overlapped portions of the resolidified regions are reduced or even eliminated.

The foregoing exemplary embodiments merely illustrate the principles of the present invention. Various modifications and alterations to the described embodiments will be apparent to those skilled in the art in view of the teachings herein without departing from the scope of the invention, as defined by the appended claims.

CLAIMS

1. A process for processing at least one portion of a thin film sample on a substrate, the method comprising the steps of:

(a) controlling an irradiation beam generator to emit successive irradiation beam pulses at a predetermined repetition rate;

(b) masking each of the irradiation beam pulses to define one or more first beamlets and one or more second beamlets, each of the first and second beamlets having two opposite edge sections and a center section;

(c) irradiating one or more first areas of the film sample by the first beamlets so that the first areas are melted throughout their thickness, wherein at least one first section of the first areas irradiated by at least one particular beamlet of the first beamlets is allowed to re-solidify and crystallize thereby having grains grown therein, the at least one first section including at least one first resolidified area; and

(d) after step (c), irradiating one or more second areas of the film sample by the second beamlets of the irradiation beam pulses so that the second areas are melted throughout their thickness, wherein at least one second section of the second areas irradiated by the at least one subsequent beamlet is allowed to re-solidify and crystallize thereby having grains grown therein, the at least one second section including at least one second resolidified area irradiated by the at least one of the edge sections of the subsequent beamlet which overlaps the at least one first resolidified area,

wherein artifacts are substantially reduced and eliminated upon the resolidification of the at least one second section of the second area.

2. The process according to claim 1, wherein the edge sections of each of the first and second beamlets are a front section and a rear section, wherein the at least one first resolidified area is irradiated by the rear section of the particular beamlet, and wherein

the at least one second resolidified area is irradiated by the front section of the subsequent beamlet.

3. The process according to claim 2, wherein the rear section of at least one particular beamlet has a width for a substantial length thereof which is smaller than a width of the center section of the at least one particular beamlet, and wherein the front section of at least one subsequent beamlet of the second beamlets has a width for a substantial length thereof which is smaller than a width of the center section of the subsequent beamlet.

4. The process according to claim 2, wherein the rear section of the particular beamlet and the front section of the subsequent beamlet have substantially straight edges which slope toward one another and away from the center section of the respective one of the particular and subsequent beamlets.

5. The process according to claim 2, wherein the rear section of the particular beamlet and the front section of the subsequent beamlet have a triangular shape.

6. The process according to claim 5, wherein each of the front and rear sections has three apexes, and wherein one of the apexes of each of the front and rear sections points away from the central section of a respective one of the particular and subsequent beamlets.

7. The process according to claim 2, wherein the rear section of the particular beamlet and the front section of the subsequent beamlet have a trapezoid shape.

8. The process according to claim 7, wherein the trapezoid-shaped rear section of the particular beamlet has a first conceptual side extending for a width of the central section

of the particular beamlet, and a second side provided at an edge of the rear section away from the central section, the first side being greater than the second side.

9. The process according to claim 7, wherein the trapezoid-shaped front section of the subsequent beamlet has a third conceptual side extending for a width of the central section of the subsequent beamlet, and a fourth side provided at an edge of the front section away from the central section, the third side being greater than the fourth side.

10. The process according to claim 1, wherein, upon the resolidification of the at least one second section of the second area, at least most of the grains from the at least one resolidified first section of the first area that are adjacent to the at least one second section grow into the at least one solidifying second section in a direction which is approximately perpendicular to a direction of extension of the at least one solidifying second section.

11. An arrangement for processing at least one portion of a thin film sample on a substrate, comprising:

a processing system controlling an irradiation beam generator to emit successive irradiation beam pulses at a predetermined repetition rate; and

a mask receiving thereon each of the irradiation beam pulses, the mask including a beam pattern which, when the beam pulses irradiate therethrough, defines one or more first beamlets and one or more second beamlets, each of the first and second beamlets having two opposite edge sections and a center section,

wherein the first beamlets irradiate one or more first areas of the film sample so that the first areas are melted throughout their thickness, wherein at least one first section of the first areas irradiated by at least one particular beamlet of the first beamlets is allowed to re-solidify and crystallize thereby having grains grown therein, the at least one first section including at least one first resolidified area

wherein, after the one or more first areas are irradiated, the second beamlets irradiate one or more second areas of the film sample so that the second areas are melted

throughout their thickness, wherein at least one second section of the second areas irradiated by the at least one subsequent beamlet is allowed to re-solidify and crystallize thereby having grains grown therein, the at least one second section including at least one second resolidified area irradiated by the at least one of the edge sections of the subsequent beamlet which overlaps the at least one first resolidified area, and

wherein artifacts are substantially reduced and eliminated upon the resolidification of the at least one second section of the second area.

12. The arrangement according to claim 11, wherein the edge sections of each of the first and second beamlets are a front section and a rear section, wherein the at least one first resolidified area is irradiated by the rear section of the particular beamlet, and wherein the at least one second resolidified area is irradiated by the front section of the subsequent beamlet.

13. The arrangement according to claim 12, wherein the rear section of at least one particular beamlet has a width for a substantial length thereof which is smaller than a width of the center section of the at least one particular beamlet, and wherein the front section of at least one subsequent beamlet of the second beamlets has a width for a substantial length thereof which is smaller than a width of the center section of the subsequent beamlet.

14. The arrangement according to claim 12, wherein the rear section of the particular beamlet and the front section of the subsequent beamlet have substantially straight edges which slope toward one another and away from the center section of the respective one of the particular and subsequent beamlets.

15. The arrangement according to claim 12, wherein the rear section of the particular beamlet and the front section of the subsequent beamlet have a triangular shape.

16. The arrangement according to claim 15, wherein each of the front and rear sections has three apexes, and wherein one of the apexes of each of the front and rear sections points away from the central section of a respective one of the particular and subsequent beamlets.

17. The arrangement according to claim 12, wherein the rear section of the particular beamlet and the front section of the subsequent beamlet have a trapezoid shape.

18. The arrangement according to claim 17, wherein the trapezoid-shaped rear section of the particular beamlet has a first conceptual side extending for a width of the central section of the particular beamlet, and a second side provided at an edge of the rear section away from the central section, the first side being greater than the second side.

19. The arrangement according to claim 17, wherein the trapezoid-shaped front section of the subsequent beamlet has a third conceptual side extending for a width of the central section of the subsequent beamlet, and a fourth side provided at an edge of the front section away from the central section, the third side being greater than the fourth side.

20. The arrangement according to claim 11, wherein, upon the resolidification of the at least one second section of the second area, at least most of the grains from the at least one resolidified first section of the first area that are adjacent to the at least one second section grow into the at least one solidifying second section in a direction which is approximately perpendicular to a direction of extension of the at least one solidifying second section.

21. A masking arrangement utilized for processing at least one portion of a thin film sample on a substrate, comprising:

at least one portion configured to receive thereon irradiation beam pulses, the at least one portion including a front section, a rear section and a center section, wherein when the beam pulses irradiate through the front, rear and center section modified beam pulses are produced which define one or more first beamlets and one or more second beamlets,

wherein the rear section of at least one portion has a first width which is smaller than a width of the center section of the at least one portion, and wherein the front section of at least one portion has a second width which is smaller than the width of the center section wherein the width of the center section, the first width and the second width are arranged substantially perpendicular to the irradiation beam pulses.

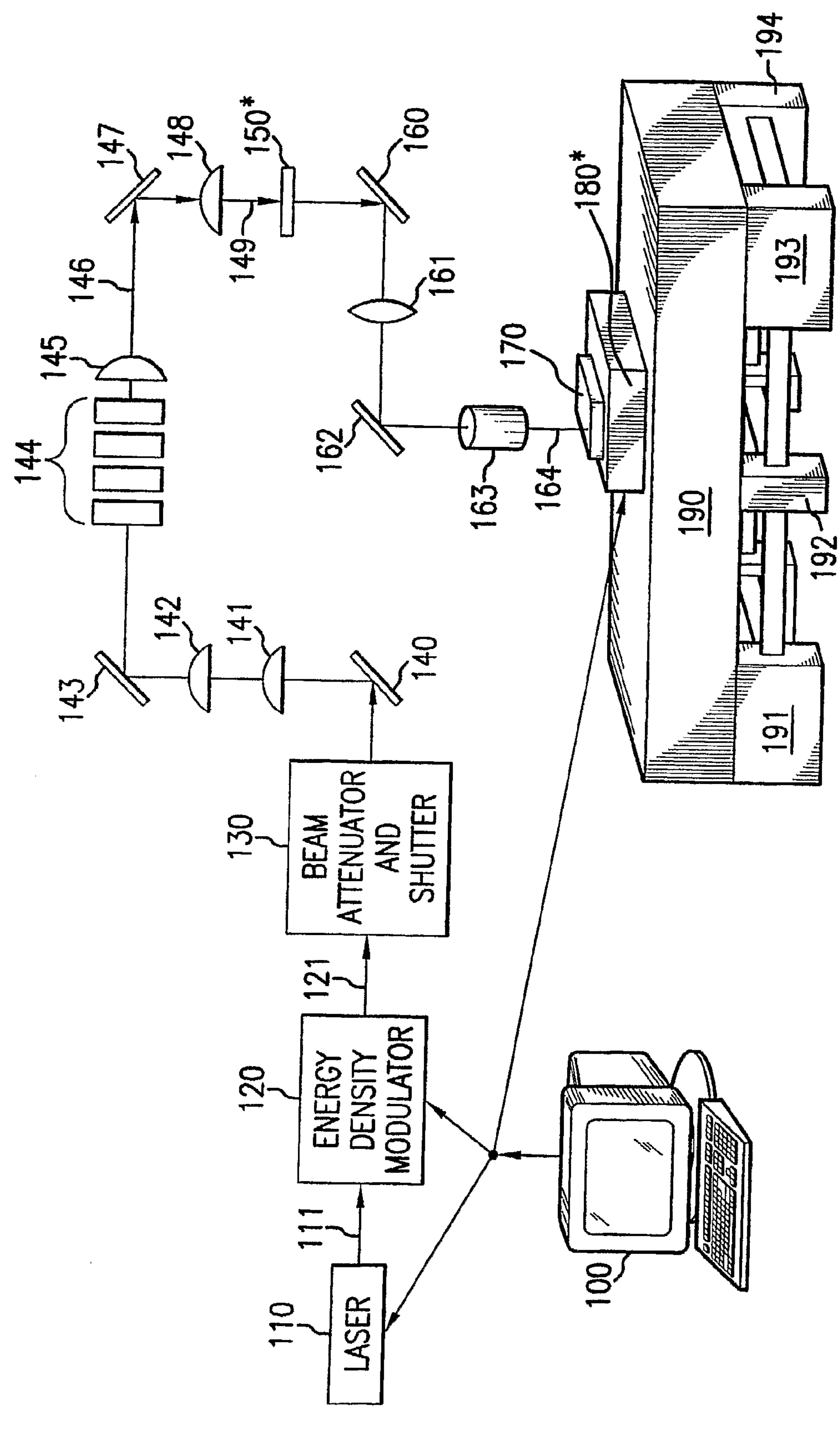
LASER
ENERGY DENSITY MODULATOR
BEAM ATTENUATOR AND SHUTTER
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FIG.1

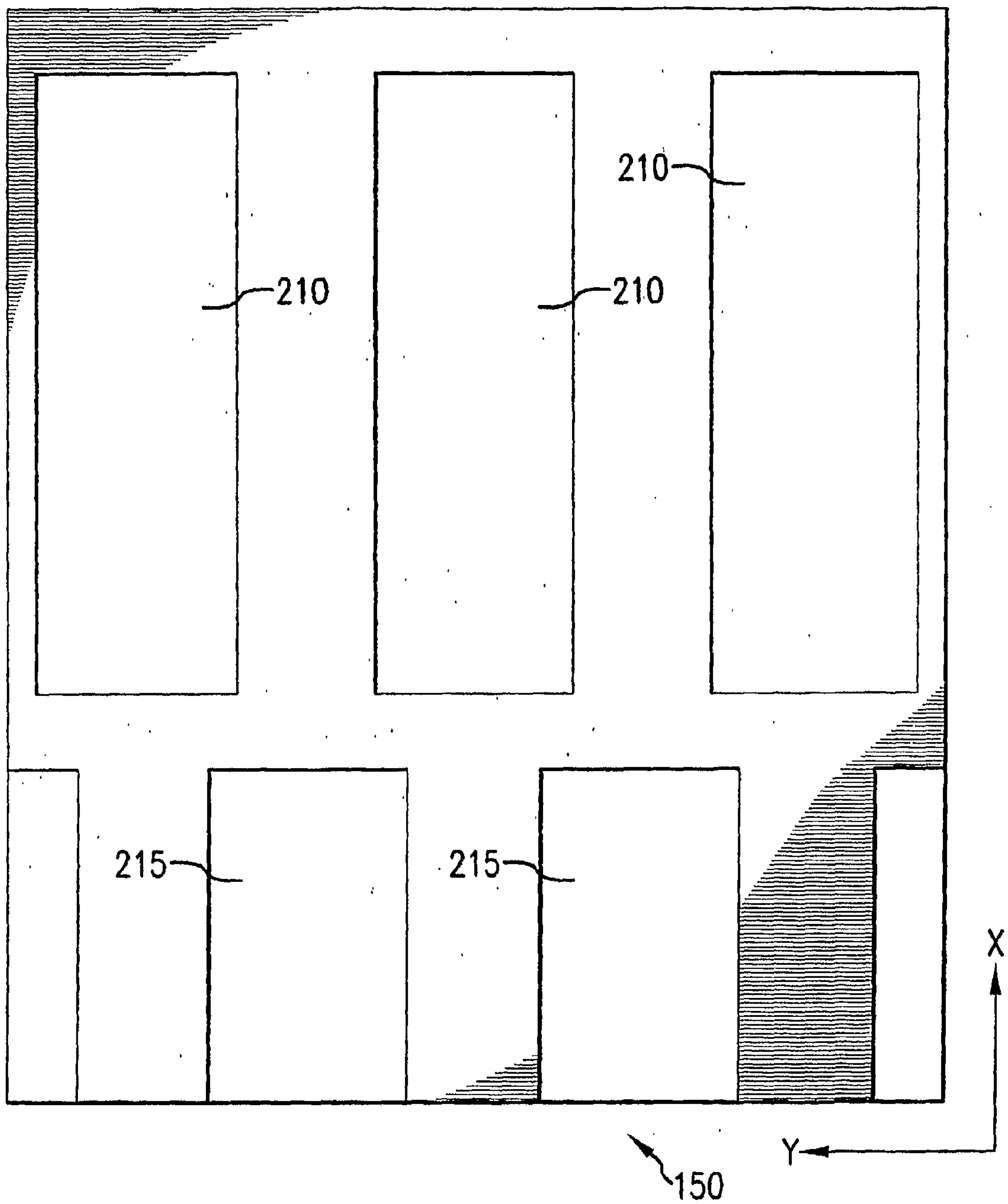


FIG.2A

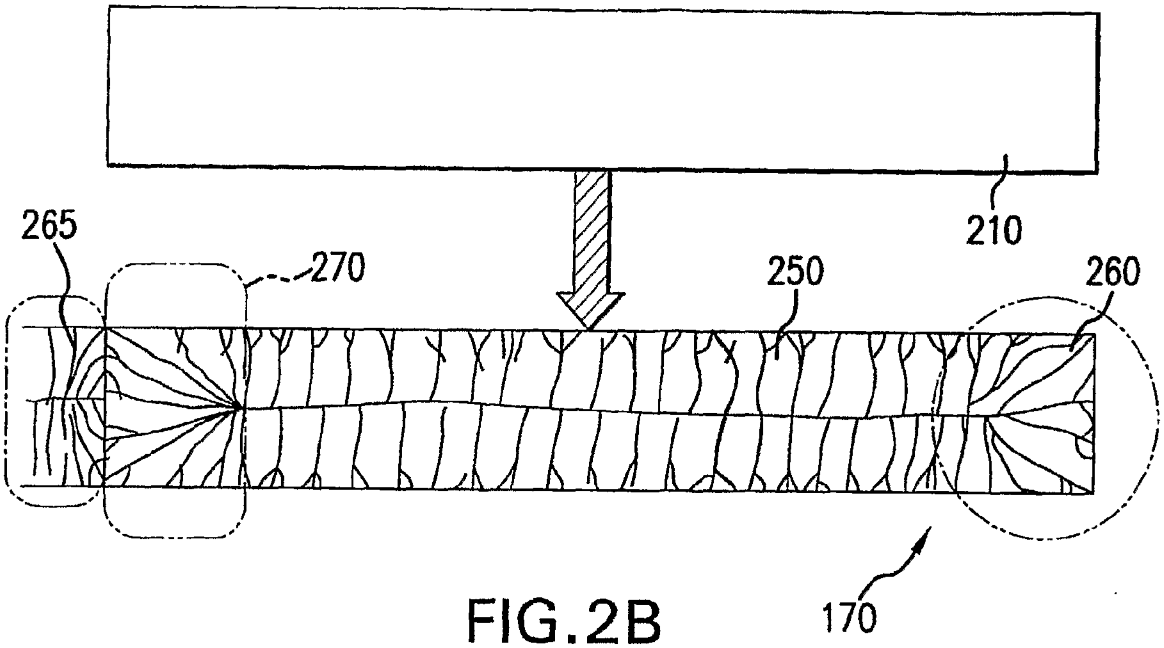


FIG.2B

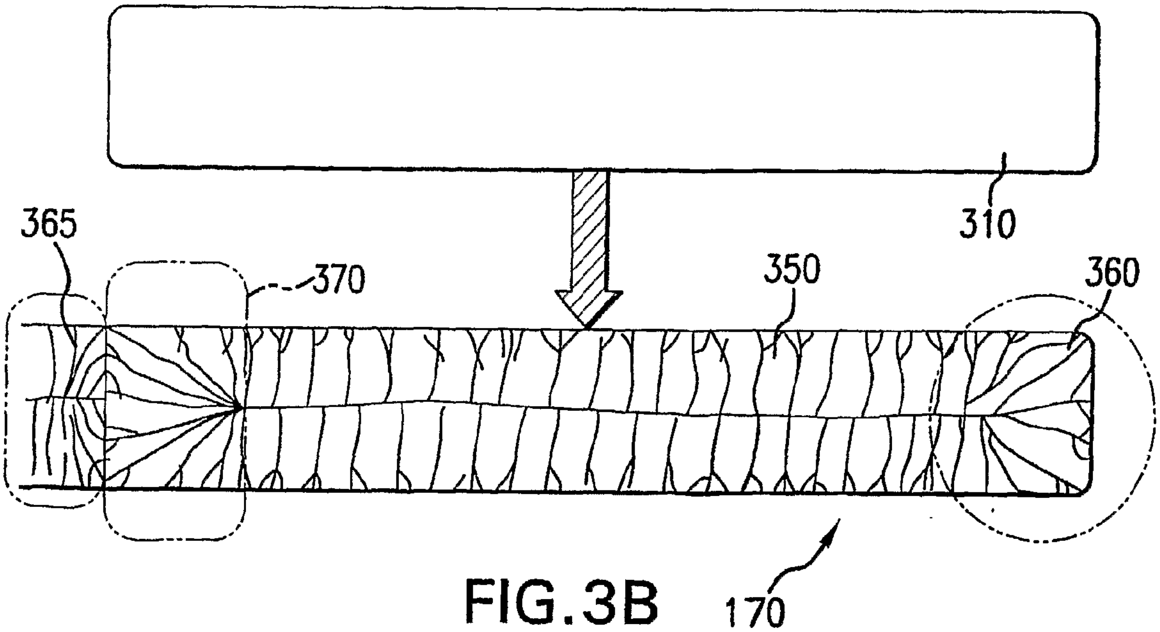


FIG.3B

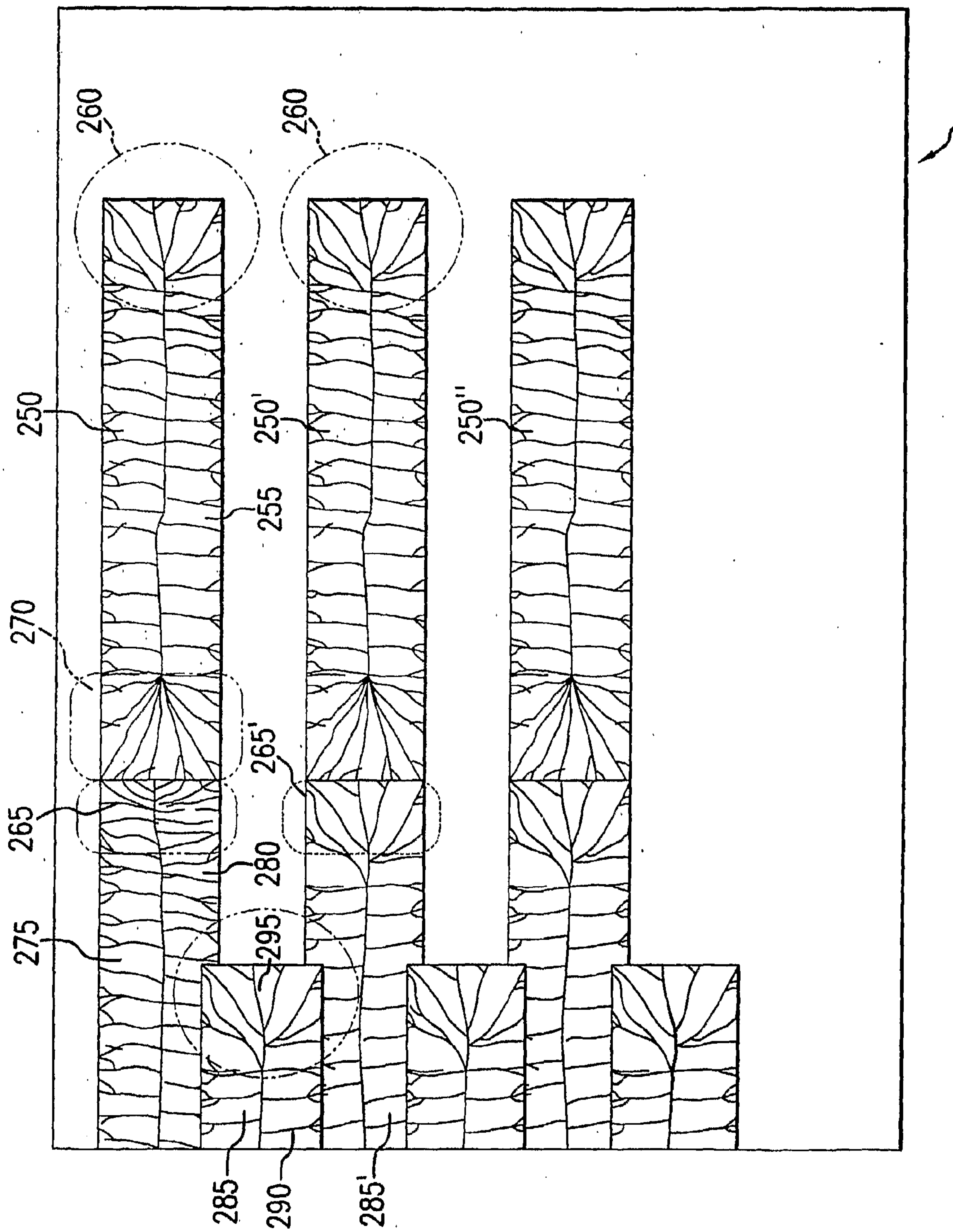


FIG.2C

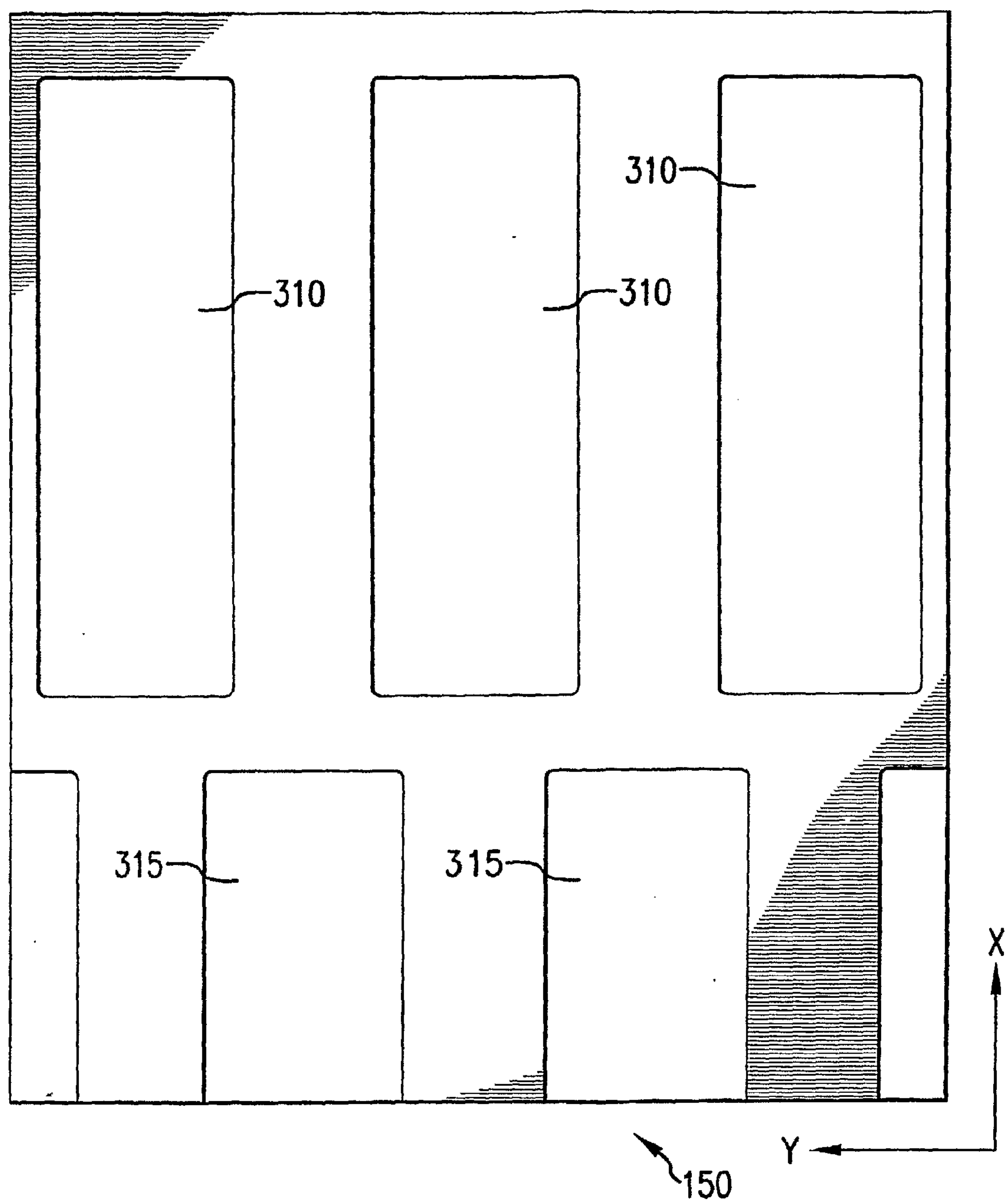
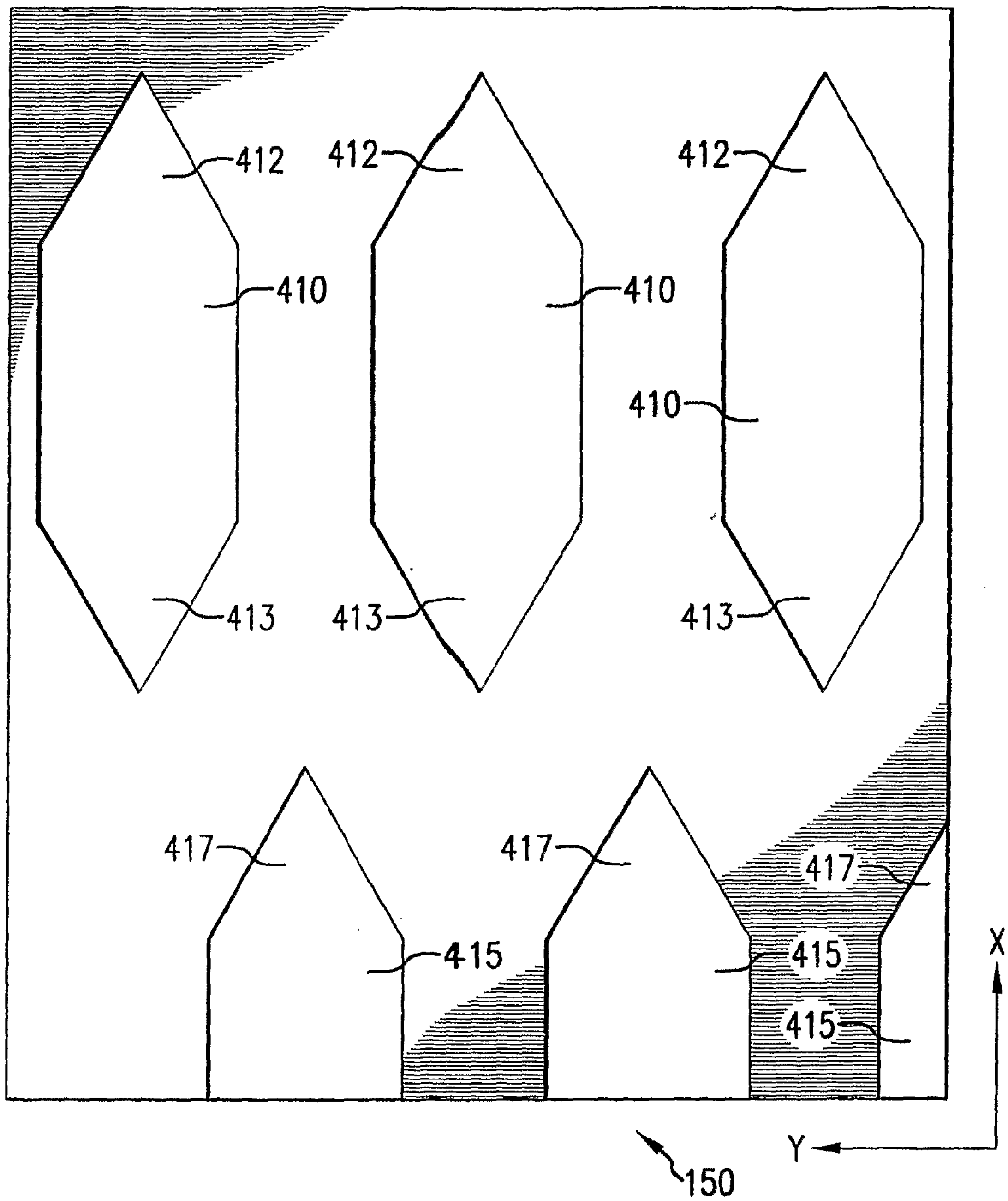


FIG.3A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Y
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FIG.4A

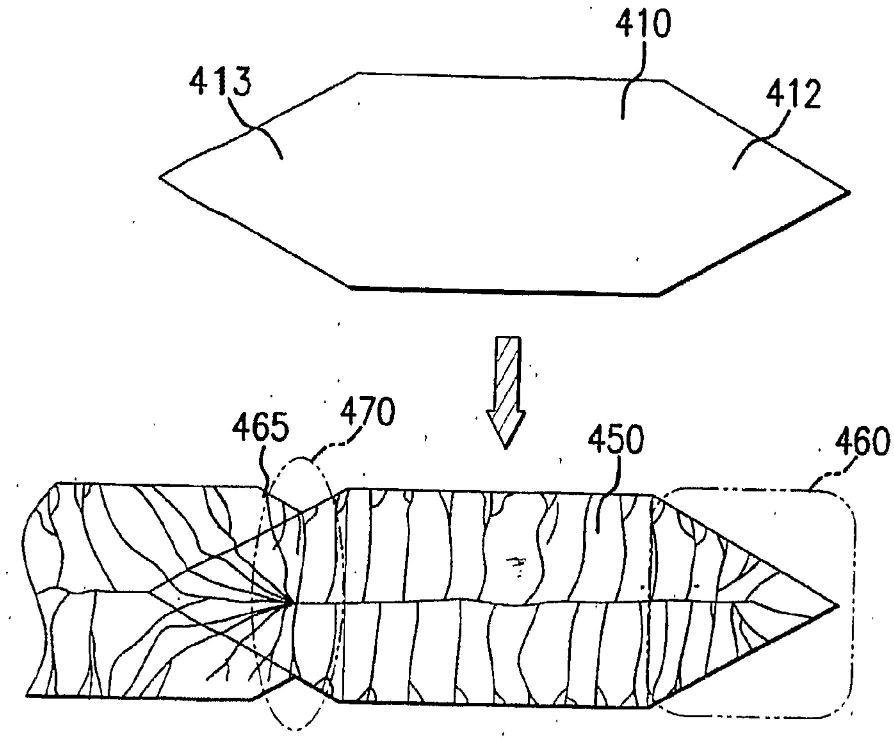

FIG.4B

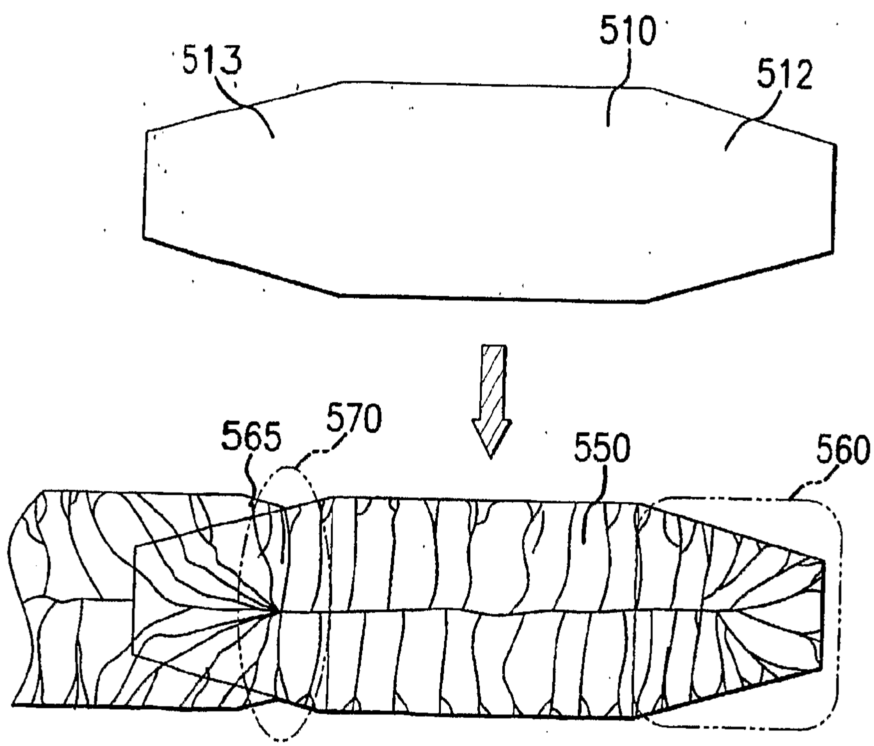

FIG.5B

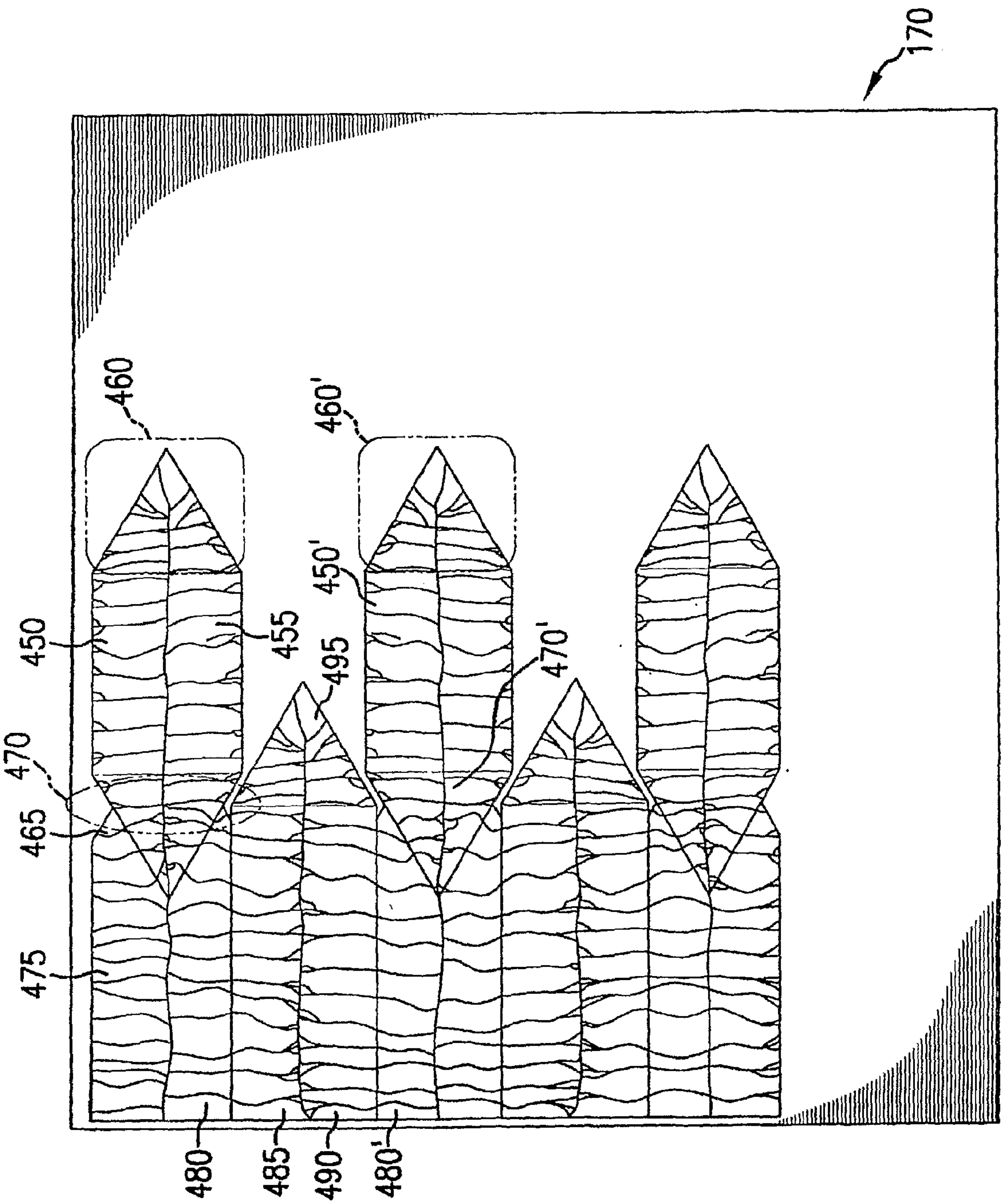

FIG.4C

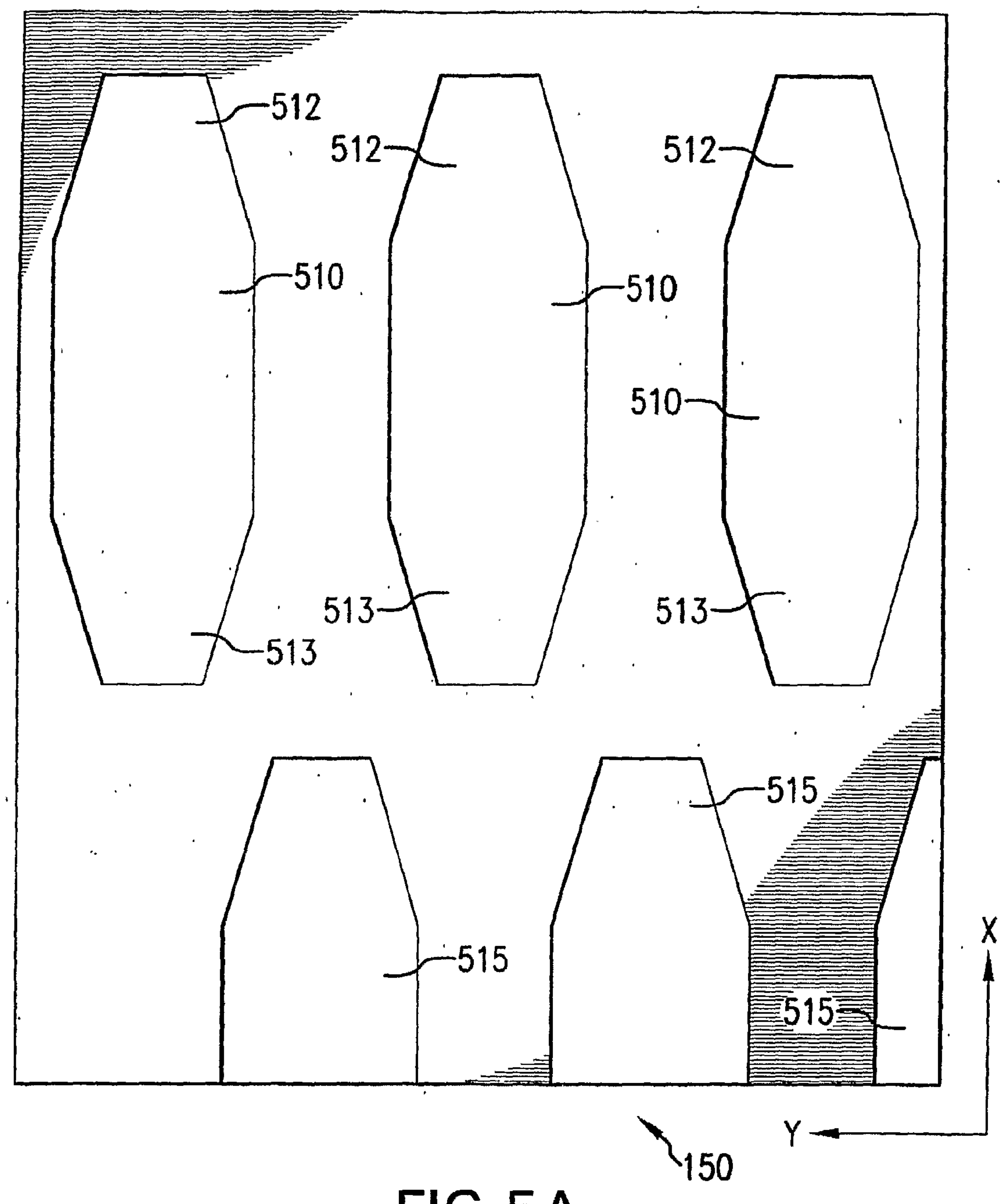

FIG.5A